Science Weekly HANDS-ON
"PUT A LITTLE SCIENCE IN YOUR WEEK"
Vol. 29, No. 01

The Kepler Space Telescope

TEACHING NOTES (TN)
Supplement of Science Weekly
Publication Pre-A through E

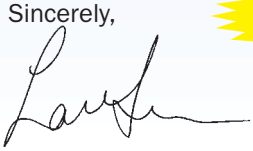
Dear Subscribers,

If you are returning for another year of ***Science Weekly***, we're glad to have you back! If you are a new teacher or parent, thank you for choosing ***Science Weekly***. We at ***Science Weekly*** are constantly striving to improve our product and to stay up to date with educational research and ever-changing guidelines for science education. We are also working to increase the resources we offer to you, the teachers and parents. We want to make it fun, easy, and rewarding for you to teach scientific content, while also integrating science with math, engineering, literacy, and problem-solving skills.

We have an exciting selection of topics planned for the months ahead. We will bring students to the forefront of technology with **The Kepler Space Telescope**, and **From Papyrus to Kindle: the Science of Reading and Writing Materials**. We will show students the relevance of science to current events with the **Science of the Summer Olympics**. We will focus on the environment with **City Farming**, **Earth's Atmosphere**, **Invasive Species**, and **Estuaries**. We will bring in a deeper look at engineering with **Housing Materials**, **Plastics**, and **Making Music with Strings**. Some issues may focus primarily on one scientific discipline, such as **Chickens** and **Blood**, which focus on biology; other issues, such as **Science in Art**, look across several scientific disciplines. With all this variety, students will never be bored, and you can be sure that every issue will reinforce scientific and critical thinking.

If you have suggestions for future topics, or any other feedback to share, we would love to hear from you! Have a wonderful year!

Sincerely,



Dr. Laura Gehl, Senior Editor

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DID YOU KNOW??
The stars Kepler observes are hundreds to thousands of **light years** away. A single light year is about 6 **trillion** miles.

Background

The Planet Hunter

The Kepler space telescope was named after German astronomer Johannes Kepler, who described the laws of planetary motion. Kepler launched in 2009 and began its mission: to look for planets around stars other than our star (the Sun). These are called *exoplanets.* So far, Kepler has confirmed 74 exoplanets. But there may be thousands, and these are only in the one area of space Kepler is studying. Kepler's field of view is in the constellations *Cygnus* and *Lyra.* This patch of sky contains more than 100,000 Sun-like stars that Kepler monitors.

Kepler "Sees" Planets Via the Transit Method

Exoplanets are very hard to detect because a star's bright light prevents us from seeing the much smaller, dark planets. Kepler scientist Natalie Bathala describes it as being like trying to see a flea walk across a distant car headlight. But Kepler's powerful *photometer* is nine times more sensitive than even the best digital cameras. Even so, it can't "see" a planet next to its star. But Kepler is able to detect the slight dimming of a star's light when a planet *transits*, or crosses, in front of it. Kepler monitors the stars in the same patch of sky in its field of view continuously, looking for the telltale "blink" of a planet transit.

Are We Alone?

There are many questions scientists hope Kepler can help answer. Is it common for stars to have planets orbiting them? Are there other planets like Earth? Might they have life? Ask your students what stories they have heard about "aliens." They can also draw or act out their ideas about life on other planets.

Part of Kepler's mission is to find planets similar to Earth. Such *terrestrial* planets are most likely to support life. These planets would be one-half to twice the size of Earth, which means they would have similar gravity. Smaller planets might not have enough gravity to hold an atmosphere. Larger planets have gravity so strong that gases couldn't escape its pull. They would be gas giants like Jupiter. For life to exist, a planet must be close enough to its star to have liquid water. A life-supporting planet would also likely have an orbit that is close to Earth's 365 days. When a planet is close to its star but not too close, it is in the *"habitable zone."* In December 2011, Kepler confirmed the first planet orbiting its star in the habitable zone – Kepler-22b.

Initiating Activity – All Levels

Because this is the first unit of the year, you may need to spend more time assessing students' prior knowledge. Do they know what a planet is? What a star is? Ask questions, show pictures to start discussion, or ask students to draw their own pictures of stars and planets. Ask if students know any movies or TV shows about space. For all students, review what we mean by "**our Solar System**." **Ask, "What gives us light during the day?"** Remind students that our Sun is a star, and tell them that our Sun has 8 planets orbiting around it, including our planet (Earth). **Ask, "Are there other stars in the sky? Why do they look so small compared with the Sun?"** Discuss with students that other stars look small because they are much farther away. Some of these other stars also have planets orbiting around them, called **exoplanets**. Kepler is looking for these planets. If possible, show students a simple telescope. Remind them that we can see the moon, the Sun, and some stars through a telescope but that we can't see exoplanets. They are too small and far away. That's why we need Kepler

(although even Kepler can't actually see the exoplanets). You may wish to show some videos at this point. Some examples are listed below.

A basic introduction to the concept of exoplanets:

http://www.youtube.com/watch?v=ewJ-YGBaAIE&feature=relmfu

NASA interactive video for children:

http://kepler.nasa.gov/multimedia/Interactives/HowKeplerDiscoversPlanetsElementary/

Many videos related to Kepler can be found at:

http://kepler.nasa.gov/multimedia/videos/

For older students, you can help them understand how far away the stars are that Kepler studies: 1 light year is 6 **trillion** miles, and these stars are hundreds to thousands of light years away (which means hundreds to thousands of trillions of miles away). **Ask, "How big is a trillion?" Say, "Let's imagine we have stacks of $100 bills. One bundle of $100 bills is equal to $10,000 and could fit in your pocket. 1 million dollars in $100 bills would fit in a shopping bag. 1 billion dollars would take up a small room in your home. But 1 trillion dollars in $100 bills would take up an entire football field! Now imagine a thousand football fields filled with $100 bills. That is a thousand trillion dollars, and the stars Kepler looks at are about a thousand trillion miles away!"**

You can also demonstrate the concept of a "flea crossing a distant car headlight." Ask a student to cut a period out of a newspaper or magazine. Tape this period onto a flashlight. When you hold the flashlight close, can students see the "flea?" What about when you are 10 meters away? 100 meters?

Initiating Questions Levels Pre-A – A

1. What is a telescope? *(an instrument that helps us see far-away objects)*
2. What are some things telescopes can see? *(any distant object, including stars and planets)*

Follow-up Questions Levels Pre-A – A

3. What is Kepler? *(a telescope)*
4. What does Kepler look for? *(planets)*

Level Pre-A

Picture Activity

Explain that **telescopes** help us see far-away objects. Telescopes can help a ship's captain spot land from far out at sea. And telescopes can help us see **planets** and **stars** in **space**. The more powerful the telescope, the more **distant** objects it can see. **Kepler**'s job is to find planets far away in space. Explain that Kepler was named for a **scientist**, **Johannes Kepler**, who described how planets move.

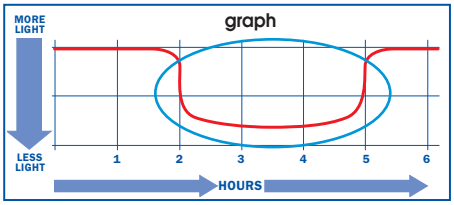
Vocabulary

Point out the planet. Kepler is finding planets that are very far away.

Weekly Lab

Students should be able to see the tiny dark planet pass in front of the white ball. This is what it might look like if we were close enough to the star. But we are very far away – so far that not even Kepler can actually see the planets. But when a planet passes in front of a star, the star's light **dims** a bit. Kepler is able to measure this **dimming**.

Level Pre-A – MATH – Solution



Math

(See Level Pre-A – MATH – Solution to the left.) Explain that the picture is a **graph**. Graphs help us **measure** things, in this case the light from a star. When the red line dips, it is because the starlight dims a bit. This is what happens when a planet passes in front of it. The part of the graph that dips below the rest is when the planet crossed in front of the star.

Storytelling

Ask students to think about whether the planet is hot or cold and if it has living things.

Challenge

Answers: Planets B and E are the same.

Explain that we don't really know what the planets might look like. Even Kepler can't actually see these planets.

Bringing It Home

Model this activity for students at school. At home, students will trim their cardboard tubes (the sloped edge is a shade for the telescope's main instrument, called a **photometer**). They will cut out and color the **solar array** (which uses sunlight to power the telescope), then tape or glue it to the tube.

Level A

Vocabulary

Students match each word to the correct picture.

Weekly Lab

(Please see Level Pre-A.)

Math

(Please see Level Pre-A.) Help students count the boxes where the red line is lower to see how many hours the light **dimmed**.

Answer: 3 hours

Writing in Science

Planets are hard to detect because they are small compared to their stars and emit no light of their own. The star's brightness obscures the small, dark **planets**. **Exoplanets** are very far away.

Challenge

Answer: Planet C looks most like Earth.

We don't really know what exoplanets look like. Even **Kepler** can't see them.

Bringing It Home

(Please see Level Pre-A.) The **antenna** is added to this level. The antenna receives information from Earth and sends information back.

Initiating Questions Levels B – E

1. What is a telescope? *(an instrument that helps us see far-away objects)*
2. Earth and other planets orbit around our Sun, which is a star. Do you think there might be other planets orbiting around other stars? How might we find those planets? Can you act out how a planet would orbit around a star? *(Ask one student to be the star and one to be the planet.)*

Follow-up Questions Levels B – E

3. What does the Kepler telescope do? *(It looks for planets around stars other than our Sun.)*

4. How does Kepler detect other planets? *(It looks for the dimming of a star as a planet transits, or crosses in front of it.)*
5. What characteristics might an exoplanet have if it could possibly have living things? *(It might be close in size to Earth and at a similar distance from its star. This is because an Earth-size planet would have enough gravity to hold the gases living things might need to breathe, but not too many gases, and a planet at a similar distance from its star would have light and warmth but not too much. The planet would have liquid water, which living things could use to survive.)*

Level B

Vocabulary
Answers will vary.

Weekly Lab
(Please see Level Pre-A.) Explain that an **orbit** is the circular path a **planet** travels around its **star**. Students should be able to see the tiny dark planet pass in front of the white ball when they are fairly close to it, but it is harder to see when they move farther away. Explain that when a planet passes in front of a star, the star's light **dims** a bit. **Kepler** is able to measure this dimming. When the dimming happens in a regular pattern, it indicates a planet orbiting the star.

Math
(Please see Level A.) Ask each student to tell you how many hours the planet is in front of the star on his or her own graph, and to show you on the graph.

Writing in Science
Answers:

1) (Please see Level A.)

2) When a star's light dims regularly, it indicates a planet in orbit around it.

3) (Answers will vary.)

Challenge
(Please see Level A.)

Answer:

1) Planet C looks most like Earth.

2) (Answers will vary.)

Bringing It Home
(Please see Level A.) Show students possible materials they might want to use when doing this activity at home. This model-making activity gives students more options than in Level A.

Level C

Vocabulary
See Crossword Puzzle Solution (above right).

Weekly Lab
Supervise carefully to make sure students do not touch hot bulbs. Students should wear safety goggles, or you can do this lab as a demonstration.

Math
Answers:

1) It means that the star's light dims a bit.

2) It means that the star's light does not dim.

3) A, B, and D might show a planet crossing the star.

4) B shows a planet crossing its star for the longest time period.

Writing in Science
Answers:

1) (Please see Level A.)

2) Scientists use light brightness graphs to see if a star's light dims at regular intervals, which would indicate a planet in orbit around it.

3) (Answers will vary.)

Challenge
The table shown contains information about Earth and Jupiter and actual data **Kepler** has gathered about several **exoplanets**. Comparing exoplanets to Earth and Jupiter can help determine whether they are similar to Earth and might have life. To help students understand the **habitable zone**, explain that it is a region around a star that is close enough for liquid water to exist on a planet, in other words, not too hot and not too cold. Planets with orbits similar to Earth's 365 days are likely to be in the habitable zone.

Answers:

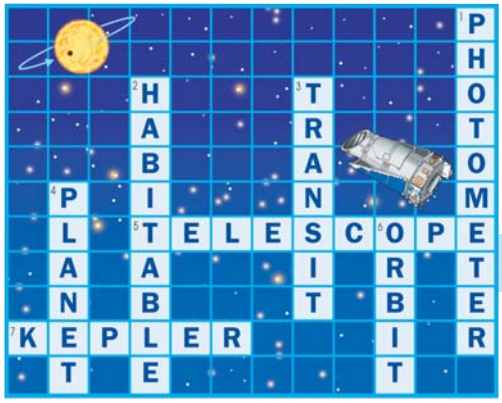
1) Kepler-9b and 30c are similar in size to Jupiter.

2) Kepler-11b is closest to its star. Jupiter is farthest away.

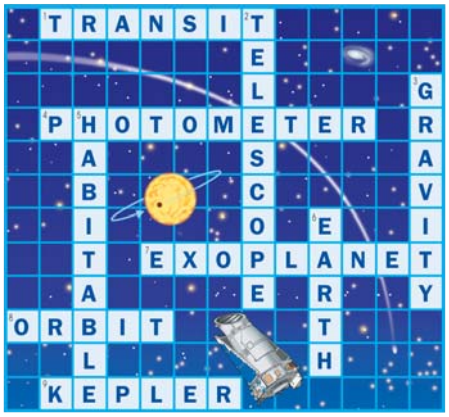
3) It is not in the habitable zone because it orbits too close to its star.

4) Kepler-22b has an orbit that is only somewhat shorter than Earth's. It is in the habitable zone of its star.

Level C – VOCABULARY – Crossword Solution



Level D – VOCABULARY – Crossword Solution



Bringing It Home
Model this activity for students before they do it at home. Suggestions for where students can find information about Kepler's parts and what they do are in the WEEKLY RESOURCES section on the last page. If students do not have Internet access at home, make sure to allow time for Internet and/or library research at school.

Level D

Vocabulary
See Crossword Puzzle Solution (bottom left).

Weekly Lab
(Please see Level C.) Here, students are asked to postulate what happens when a planet **transits** a star.

Math
Answers:

1) It means that the star's light dims a bit.

2) It means that the star's light does not dim.

3) A, B, D, and F might show a planet crossing the star.

4) C and E show no planets in orbit.

5) B shows a planet crossing its star for the longest time period.

Writing in Science
(Please see Level C.)

Challenge
(Please see Level C.)

Answers: *(Please see Level C for answers 1–3.)*

4) Kepler-22b and 34b have similar orbits to Earth and are in the habitable zone.

5) Kepler-22b is most similar to Earth. It is twice as large as Earth.

Bringing It Home
(Please see Level C.)

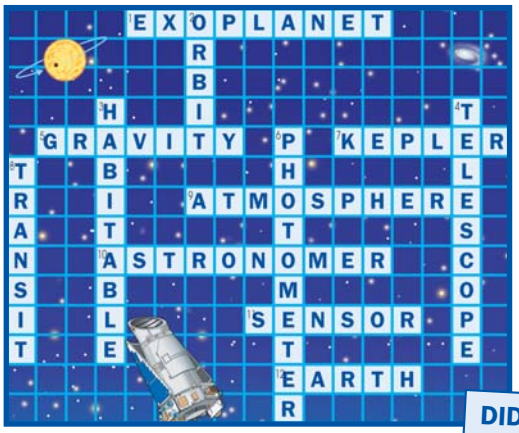
DID YOU KNOW??
The **habitable zone** around a star is often called the **Goldilocks zone**: It is "just right" for life.

DID YOU KNOW??
Kepler's **field of view** contains more than 100,000 Sun-like stars.

Level E

Vocabulary
See Crossword Puzzle Solution below.

Level E – VOCABULARY – Crossword Solution



DID YOU KNOW??
Kepler has a **95-megapixel digital photometer**. A really good photographer's camera might have 10 megapixels.

Weekly Lab
(Please see Level D.)

Math
Answers:

1) A, B, D, and F might show a planet crossing the star.

2) C and E show no planets in orbit.

3) B shows a planet with a longer orbit than the others.

4) A longer orbit means that the planet is farther away from its star than a planet with a shorter orbit.

Writing in Science
Answers: *(Please see Level C for answers 1–2.)*

3) Light brightness graphs can also provide information about the length of a planet's orbit and how close it is to its star.

4) (Answers will vary.)

Challenge
(Please see Level D.)

Answers: *(Please see Level C for answers 1–3 and Level D for answer 4.)*

5) Kepler-22b is most similar to Earth, although it is twice as large. Gravity on this planet would be greater than on Earth, so life would have to be adapted for such conditions. For example, living things might not grow as tall or be as thin as those on Earth. (Answers will vary.)

Bringing It Home
(Please see Level D.) Here the parts of Kepler are not labeled; students must do their own research to identify the names and functions of each part.

Weekly Resources

Helpful Sources for Planning Your Science Weekly Classroom Activities

Recommended Resources

- Donald, Rhonda Lucas. **Life on Other Planets**. New York, NY: Franklin Watts, 2003.
- Gow, Mary. **Johannes Kepler: Discovering the Laws of Planetary Motion**. Berkeley Heights, NJ: Endlow Publishers, 2003.
- Kops, Deborah. **Exploring Exoplanets**. Minneapolis, MN: LearnerClassroom, 2011.
- Wittenstein, Vicki Oransky. **Planet Hunter: Geoff Marcy and the Search for Other Earths**. Honesdale, PA: Boyds Mills Press, 2010.

Internet Resources

http://www.nasa.gov/mission_pages/kepler/news/keplerm-20110617.html

http://planetquest.jpl.nasa.gov/

http://kepler.nasa.gov/images/videos/ARC-KeplerOverview-480p.mov.

http://www.seti.org/kepler

http://kepler.nasa.gov/Mission/JohannesKepler/

Formal definitions for most vocabulary words can be found at:
http://www.merriamwebster.com

Alignment with A Framework for K–12 Science Education (developed by the National Research Council [NRC] July, 2011

Dimension 1
1: Asking questions
2: Developing and using models
4: Analyzing and interpreting data

Dimension 2
1: Patterns
2: Cause and effect
3: Scale, proportion, and quantity

Dimension 3
ESS1: Earth's place in the universe
ETS1: Engineering design

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